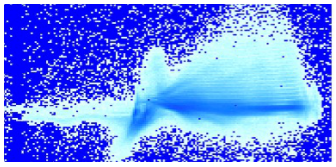

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Coherent Surface Scattering Imaging with Nanometer Resolution for 3D Mesoscale Structures at Surfaces and Interfaces

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Many nano and quantum devices have intricate, low-dimensional, non-uniform, or hierarchical structures, spanning from millimeters down to sub-nanometer sizes, on surfaces and interfaces, making high-resolution surface-sensitive characterizations imperative for understanding their function-structure relationship. This often entails visualizing surface-supported and buried planar mesoscale structures, which can be done non-destructively by high-resolution X-ray imaging and scattering techniques. Newly developed Coherent Surface Scattering Imaging (CSSI), which operates in grazing-incidence reflection geometry [1], effectively tackles the aforementioned challenges. We will present several recent advancements to illustrate the capabilities of different imaging techniques within the framework of CSSI. For example, hard X-ray ptychographic reflectometry imaging merges the two-dimensional imaging capabilities of hard X-ray ptychography with the depth profiling capabilities of X-ray reflectivity, for surface and interfacial structures [2]. The amplitude and phase information obtained from ptychography reconstructions at various reflected angles not only reveals surface topography and localized structures such as shapes and electron densities but also provides statistical details such as interfacial roughness. Moreover, employing advanced 3D finite-element-based multibeam-scattering analysis enables the extraction of heterogeneous electric-field distributions and high-resolution 3D mesoscopic surface structures [3]. This holography imaging method holds great potential for single-shot structural metrology, allowing visualization of irreversible and morphology-transforming physical and chemical processes in situ or operando. Additionally, we will introduce the unique CSSI beamline currently under construction for APS Upgrade [4]. Achieving spatial resolution in the order of a few nanometers in all three dimensions is made possible by state-of-the-art wavefront-preserving X-ray optics for 2-D focusing, high-precision motion-decoupled nano-positioning stages for surface alignment and scanning, and a cutting-edge vacuum detector system ensuring sufficient imaging oversampling in a reflection geometry. We will also discuss the potential for further development of CSSI.

References:
1. Sun, Tao, Zhang Jiang, Joseph Strzalka, Leonidas Ocola, and Jin Wang. "Three-dimensional coherent X-ray surface scattering imaging near total external reflection." Nature Photonics 6, no. 9 (2012): 586-590.
2. Myint, Peco, Ashish Tripathi, Michael J. Wojcik, Junjing Deng, Mathew J. Cherukara, Nicholas Schwarz, Suresh Narayanan, Jin Wang, Miaoqi Chu, and Zhang Jiang. "Three-dimensional Hard X-ray Ptychographic Reflectometry Imaging on Extended Mesoscopic Surface Structures." arXiv preprint arXiv:2402.06762 (2024).
3. Chu, Miaoqi, Zhang Jiang, Michael Wojcik, Tao Sun, Michael Sprung, and Jin Wang. "Probing three-dimensional mesoscopic interfacial structures in a single view using multibeam X-ray coherent surface scattering and holography imaging." Nature communications 14, no. 1 (2023): 5795.
4. https://www.aps.anl.gov/Beamlines/Directory/Details?beamline_id=221

Primary authors: Dr JIANG, Zhang (Argonne National Laboratory); Dr MYINT, Peco (Argonne National Laborartory); Dr CHU, Miaoqi (Argonne National Laboratory); Dr TRIPATHI, Ashish (Argonne National Laboratory); Dr WANG, Jin (Argonne National Laboratory)

Co-authors: Prof. SUN , Tao (Argonne National Laboratory and Northwestern University); Dr WOJCIK, Michael J. (Argonne National Laboratory); Dr SPRUNG , Michael (Deutsches Elektronen-Synchrotron DESY); Dr DENG, Junjing (Argonne National Laboratory); Dr CHERUKARA, Mathew J. (Argonne National Laboratory); Dr SCHWARZ, Nicholas (Argonne National Laboratory); Dr NARAYANAN, Suresh (Argonne National Laboratory)

Presenter: Dr MYINT, Peco (Argonne National Laborartory)

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